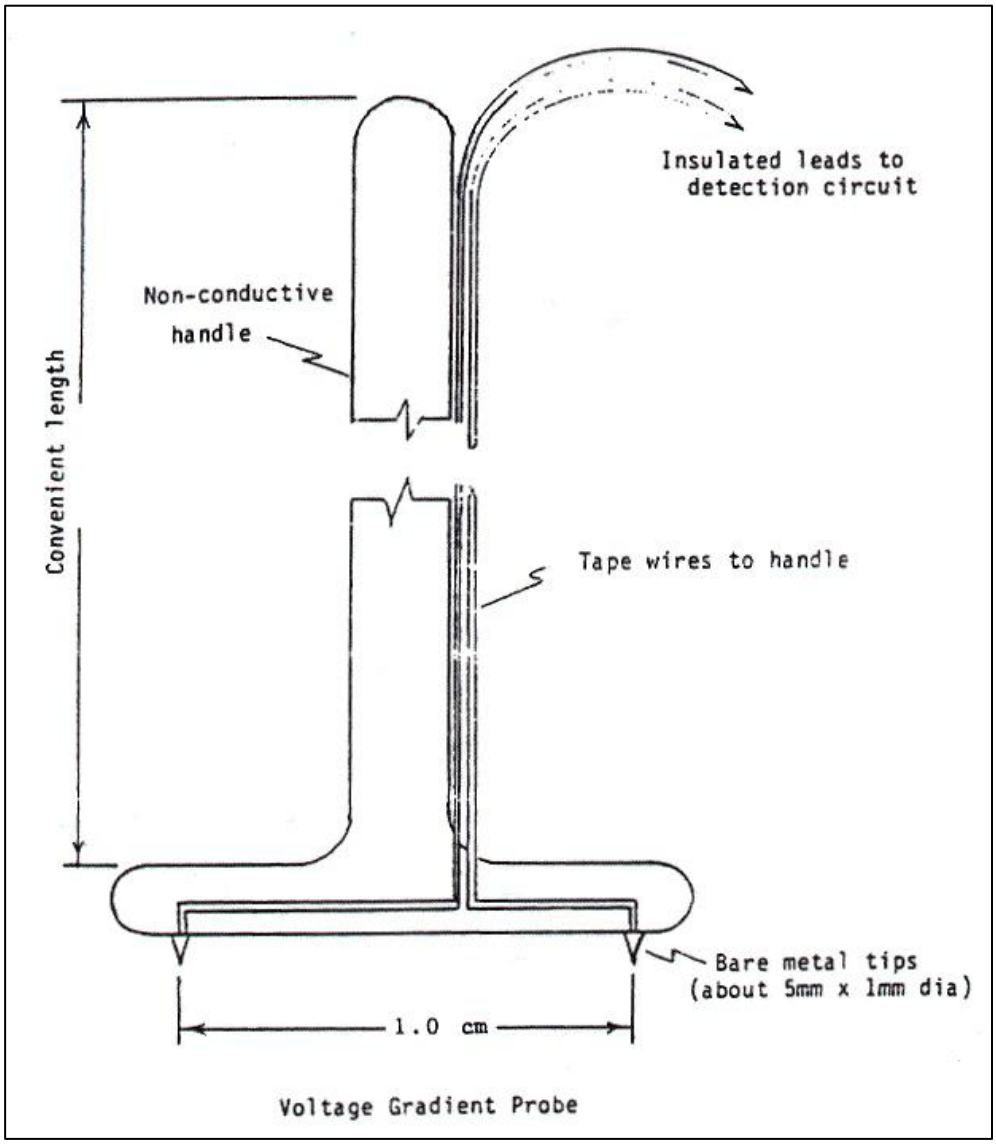
Voltage Gradient Probe construction

The following are a set of schematics and pictures of parts used to build a voltage gradient probe.

Basically, the probe is a non-conductive rod (hollow or solid) that carries the test leads and provides structure for a constant separation distance for the electrodes.



Parts List

2	Banana plugs, one red, one black (to connect to multimeter or oscilloscope)
2	Wire as speaker cable, 18 gauge, length of appropriate size (with dual-pin male ends [two pins])
1	1” PVC pipe (Schedule 40 is fine), ≥ ½ inch inside diameter, 2 feet long or a convenient length
1	1” PVC cap (can use 2 caps to enclose each ends)
1	Red tape (or paint, marker)
1	Pins for electrodes (solder on the end of the exposed wire ends works but recommend pins so that the electrodes will have a regular, cylindrical shape
1	Epoxy or silicon seal

Optional: PVC tee (if you are going to have a larger electrode separation distance)

Equipment List

Soldering gun with rosin-core solder
Drill with small bit for drilling 18 gauge holes in cap
Diagonal pliers (dikes) aka side cutters for cutting wire and pins
Ruler with 1 cm gradations
Optional: Continuity tester (ohmmeter), red and black permanent markers

Procedure

Drill two holes in cap 1 cm apart center to center, each ½ cm from center of cap

Place speaker cable pins through holes; dry fit to pipe first to confirm proper fit, then remove pipe

Apply epoxy or silicon seal in PVC cap to secure in place and waterproof the speaker cable pins which are extending through the holes in the cap. Quickly mate the pipe to the cap with the speaker wires running though pipe. Either put silicon seal or epoxy in the other end of the pipe alone or with a cap through which a larger hole has been drilled such that the speaker wires can pass. Allow epoxy or silicon seal to dry overnight.

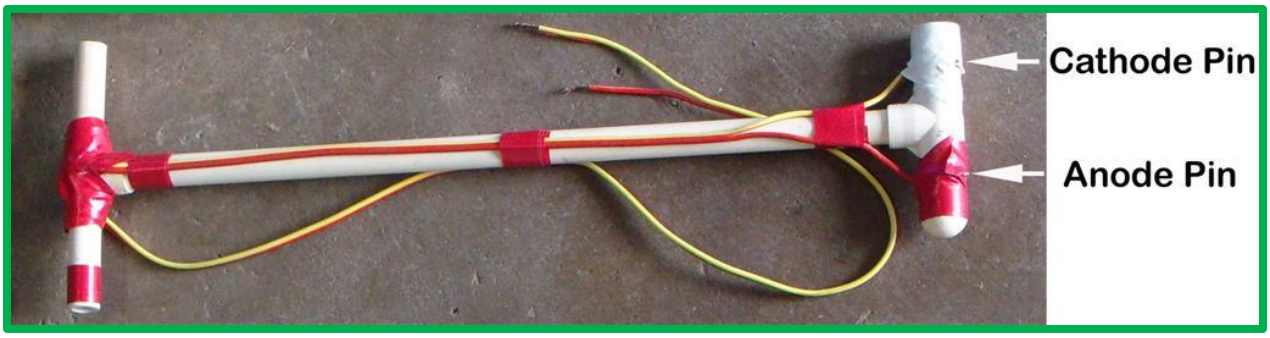
Let project from the top end of the pipe enough speaker wire (at least about 4 ft or 120 cm) for connecting to the meter which will be used for measuring the voltage gradients. Cut the speaker wires to the desired length and solder the banana plugs to the ends of the wires. Cut pins such that they project approximately 2-3 mm from end of cap. Verify center-to-center distance between pins (should be about 1 cm, but record actual distance). **NOTE: recent work by Jan Dean has demonstrated that erroneous voltage gradient readings are likely in ambient water conductivity below 100 µS/cm, particularly with short electrode pins (<2 mm). When mapping electric fields, attempt to map only in water conductivity at or greater than 100 µS/cm. If you must map in sub-100 µS/cm conductivity, use voltage gradient probes with pins at least 7 mm in length.**

Check continuity from banana plugs to pins. Mark top of pipe (or top cap) and bottom cap as to polarity with a red and/or a black permanent marker, if desired.


RadioShack
24-FT. (7.31M) SPEAKER CABLE


RadioShack
BANANA PLUG
ENCHUFE TIPO BANANA
274-007
RadioShack
TECHNOLOGY
18-Gauge
24-FT. (7.31M) SPEAKER CABLE
CABLE PARA ALTAVOZ MACHO DE DOS CLAVIJAS CALIBRE 18 DE 7.31 M (24 PIES) A MACHO DE DOS CLAVIJAS
Dual-Pin Male to Dual-Pin Male
42-2455

Anatomy of a voltage gradient probe. Note that red tape or paint denotes the anodic side.



You can run the wire through the PVC handle or taped along the outside of the rod.

Electrode ends should be exposed about 5mm and be about 1mm in diameter.

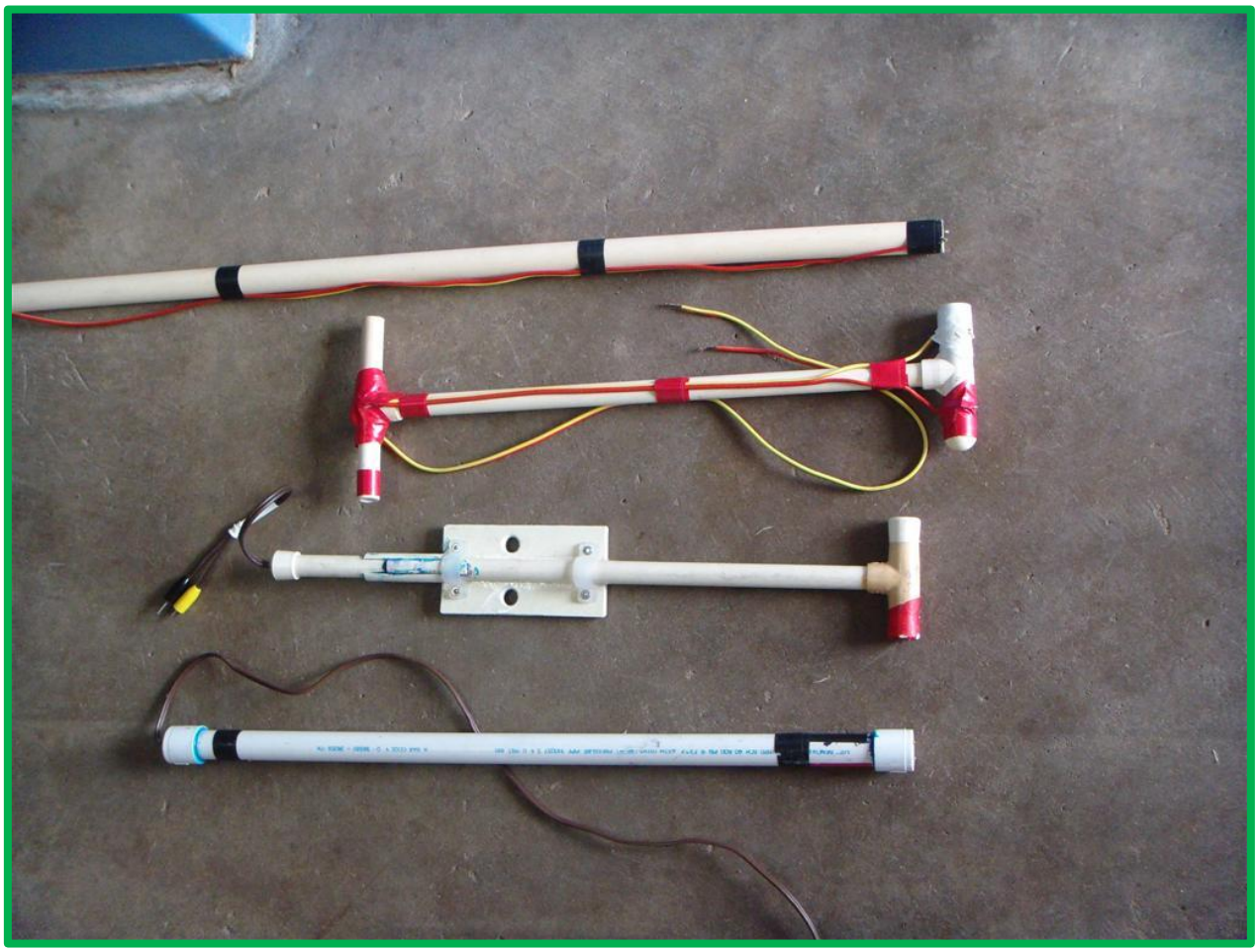
The electrode separation distance depends upon your objective. A wider separation (2-3 cm) between pins will allow you to measure lower voltage gradients and with less round-off error. However, a narrower distance (1 cm or less) between pins will provide a more accurate reading near the electrode. (You are measuring a slope [tangent on a curved line], so a wide distance between pins will induce more error in reading the tangent when the slope is changing a lot over very small distances). It is turning out that the most important measurements are occurring within 150 mm of the electrodes so a 1-cm separation distance may be the best bet initially.

Equipment testing in homogeneous field test tanks has shown that the distance in voltage gradient (V per distance in cm) is measured from center to center of the electrodes. So, to get a voltage gradient measurement, divide the voltage reading taken by the probe electrode separation distance. For example, using a probe with an electrode separation distance of 1.1 cm and with a reading of 1.63 V results in a voltage gradient of 1.63 ÷ 1.1 = 1.48 V/cm.

Make sure you measure the separation distance accurately and perhaps confirm voltage gradient readings in a homogeneous electrical field produced in a tank. The homogeneous field produces a known voltage gradient (voltage applied ÷ electrode separation distance in cm).

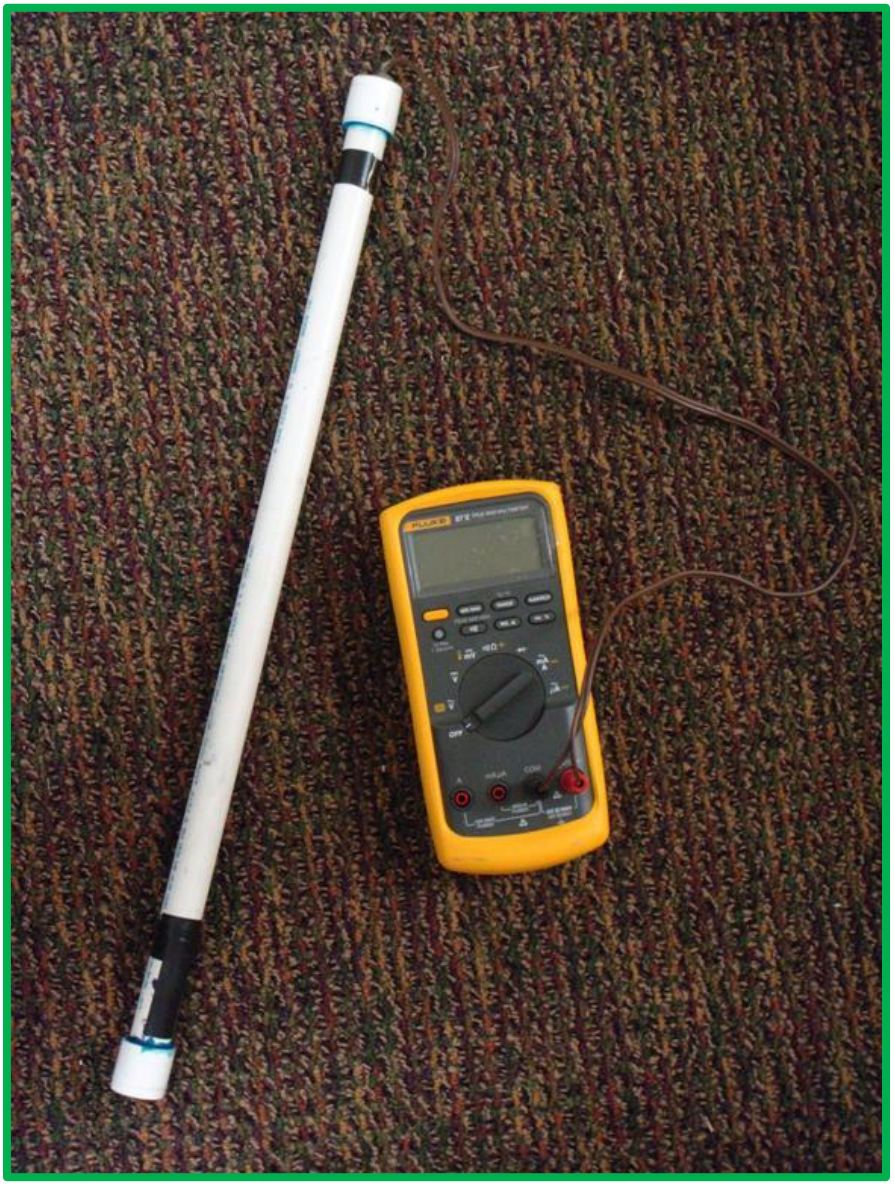
Separation distance: 1.1 cm

Some examples:



Probe bottoms showing different electrode separation distances.

Complete set of voltage gradient probe and meter:



If the output waveform of the electrofishing gear is direct current (DC), then commonly available multimeters can be connected to a voltage gradient probe and used. Otherwise, if the equipment output is pulsed direct current (PDC) or alternating current (AC), then a peak-reading multimeter is required (example is the Fluke 87-V multimeter pictured above).

Caveat: Pulsed direct current waveforms may exhibit transient spikes generated by units that have less expensive components, degraded components, or are under significant load in high conductivity water. Also, direct current may have a significant "ripple" or saw-tooth pattern instead of a relatively flat voltage output. An oscilloscope (or scopemeter) is required to view waveform shape. If your machine outputs a spiked waveform, then two questions are 1) where on the waveform should peak voltage be measured, and 2) where on the waveform does the testing multimeter measure peak voltage? For the time being, we have adopted a standard

that defines peak voltage of a spiked pulse to be the uppermost point having a pulse width equal to one millisecond. The second question can be answered only by checking with a scopemeter. The best situation is for agency personnel to have access to a scopemeter at least to make initial checks on waveform shape.